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Negative effect of protective bag on trawl codend selectivity

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This study investigated the differences of selectivity between a plain codend and a codend surrounded with a protective bag. The experiments were carried out in the İskenderun Bay, located in the eastern Mediterranean Sea, between 15 January and 15 March 2012, when the amount of trawl catch was the lowest in the fishing season. The experiments were conducted on board Ali Kaptan-6 (22 m, 500 hp main engine) by employing a conventional bottom trawl commercially used in İskenderun Bay. The hooped covered codend method was used to obtain selectivity data. Eight valid hauls were carried out both with codend and protective bag. The data were collected for brushtooth lizardfish (*Saurida undosquamis*) and Randall's threadfin bream (*Nemipterus randalli*) which were Red Sea migrants and dominated fish for trawl catch in the area. Selectivity parameters were obtained by using logistic equation with the maximum likelihood method. As a result, protective bag had negative effects for especially the brushtooth lizardfish on codend selectivity, although the species were very successful in escaping trawl codend mesh openings due to is fusiform body.

[**Keywords:** Mediterranean Sea; Trawl; Codend selectivity; Protective bag]

Introduction

A protective bag for trawling is cylindrical surrounding net that protects the main bag from the attack of aquatic animal creatures and negatives in the sea bottom[1]. Major external factors are the contact with the ground and the hit by dolphins. According to the related legal regulations, the mesh size of the protective bag must be at least twice as that of the main codend. This is no clarified meaning of 'protective bag' in the European Commission Regulations[2]. In different commercial trawl fisheries applications, there is concern that this uncertainty is adversely[3-6].

In the Scottish demersal trawl, Kynoch et al. (2004)[4] compared 110 and 120 mm codend with the strength (protective) bag for haddock. The strength bag had different effect on the codend size selectivity parameters L_{50} and selection ranges (SR). The L_{50} value was 29.5-32.4 cm and was 31.4- 34.3 cm for 110-120 mm codend with and without a strengthening bag, respectively. The SR were constant for the 110 and 120 mm codend with and without the strength bag as 4.5 and 5.2 cm, respectively.

When the effect of protective bag was investigated on size selectivity of Aegean Turkish demersal trawl codend, whenever increasing the number of mesh around the protective bag resulted in a 14% and 4% increase in the L_{50} for hake and mackerel, respectively[5]. No sufficient information has been published on the effect of the protective bag, in especially demersal trawl fishing area with high species diversity[1].

There was a prediction that while fishermen use a protective bag to support main trawl codend, they may aim to reduce the selectivity by masking the mesh open of codend. A similar method of masking effect is using a double codend, which impedes the escapements of significant proportions of common pandora and annular sea bream[7].

This study was conducted to investigate the impact of protective bag on the selectivity in trawl codend used in the Iskenderun Bay. The Bay has a high demersal trawl fishing area where species diversity was intensively targeted to fish and shrimp species with high economic value[8-10]. In addition, due to climate change these are instance of migration of lessepsian fish species[11]. In this study, effects of the protective bag were investigated on size selectivity for lessepsian brushtooth lizardfish and Randall's threadfin bream that have now great importance in the trawl fishery.

Materials and Methods

The study was carried out using a commercial fishing vessel during February to March 2012, which could be described as the end of the season. During

this period, especially when the catch amount of trawl fishing in the area decreases, the trawl fishermen want to catch even little brushtooth lizardfish escaping from the mesh open by fusiform body[6]. Therefore, the fishermen used different ways to prevent the escape of fish from trawl codend mesh; main codend mesh open masking with protective bag has been most commonly used. In the study, a commercial bottom trawl gear with 1200 meshes around the fishing circle was used in all trawl hauls by the commercial trawler named, ALI KAPTAN-6. This gear had a combined trawl model traditional and modern system common for the multi-species in the Mediterranean trawl fishery aimed at catching both fish and crustaceans[12].

A total of 27 trawls were performed at depths range 45-75 m, in towing duration of 181-210 minutes, with towing speeds of 2.8 and 3.1 knots. A total of 16 hauling was used for this research due to rupture of the net, dolphins' hitting the net, etc. Eight of these trawls were carried on with a protective bag and the remaining eight were performed without a protective bag. The fish were separated and evaluated separately in terms of cover and codend following each trawl.

Table 1 — Features of codend, cover and protective bag in the study

	Codend	Cover	Protective Bag
Material	PE	PE	PP
Opening mesh size (mm)	44.7	22.5	91
Rope thickness	960 Rtex	450 Rtex	3 mm
Mesh number of around	300	750	150
Length (m)	6	9	6
Woven method	Textile	Textile	Hand weave

Factory-woven, polyethylene fishing net with 44 mm diamond mesh made of 960 Rtex was used as the trawl codend in this study. The protective bag used by the fishermen was a legal net made of polypropylene ropes of sizes 30 mm. The features of these nets and the codend covered are given in Table 1.

Hooped covered codend method was used in this study for estimating size selectivity. It was only possible to calculate the selectivity parameters for brushtooth lizard fish and Randall's threadfin bream using the logical selectivity method by fitting the logic function: $r(l) = (\exp(a + bl))/(1 + \exp(a + bl))$ by means of maximum likelihood method[13,14], where a and b are parameters to be estimated. Selectivity parameters and curves of the individual hauls and pooled data were obtained by using Proc NLMixed analyses[15]. (PROC NLMIXED DATA = Su METHOD = GAUSS ABSGCONV = 0.000001[…]; total = codend + cover; work=(q1/q2)*exp(2*log(3) * (lenclass - (meanL50 + L50 + theta1 * wgt)) / (meanSR + SR + theta2 * wgt)); r = work / (1 + work).

Results

A total weight of about 374.46 kg without protective bag and 369.93 kg with protective bag was caught in the session of Iskenderun Bay deep trawl fisheries. Brushtooth lizardfish was dominant species in all of them. Randall's threadfin bream was second

Table 2 — Total catch (kg) as species in codend and covers circumferences, with and without protective bag in Iskenderun trawl fishery

	Protective Bag			
	Without		With	
	kg	%	kg	%
		Total catch		
codend	307.21	100	337.91	100
cover	57.25		32.02	
		Brushtooth lizard fish		
codend	105.20	39.70	118.24	36.80
cover	39.55		18.19	
		Randall's threadfin bream		
codend	23.35	7.47	22.73	6.90
cover	3.90		2.63	
		Other catch		
codend	124.25	37.50	135.42	37.50
cover	12.50		3.4	
		Discard (fish)		
codend	54.41	15.20	61.52	18.70
cover	1.30		7.80	

Table 3 — Selectivity parameters for Brushtooth lizard fish and Randall's threadfin bream, with and without protective bag in Iskenderun trawl fishery

		Mean		theta1	theta2	q1	q2	wgt	Var	
		L_{50}	SR						L_{50}	SR
Brushtooth lizard fish	With	14.75	12.28	0.4	2.3	1.4	0.3	1.1	3.5	6.8
	Without	16.44	6.17	0.7	1.3	4.9	4.3	-0.1	8.2	9.7
Randall's threadfin bream	With	9.34	3.45	0.4	1.5	0.8	1.2	-0.5	3.4	3.1
	Without	10.02	1.8	0.7	0.3	0.7	0.1	0.2	2.4	1.71

most dominant species in two different situations of trawl hauling (Table 2).

In this season, although the amount of catch was very low the diversity of species was not low when compared with the catch during beginning season of annual trawl fishing. In the region, other main economic fish species were: *Pagellus erythrinus, Mullus barbatus, Sparus aurata,* and *Trachurus spp.* for the trawl fishery study with catch amount. However, the quantum of these species and other economic catches was very low at this time of the year for trawl fishery in the Iskenderun Bay.

Brushtooth lizard fish

A total of 4934 brushtooth lizardfish were caught in this study. For each position of trawl codend, the size of the fish ranged from 8 cm to 26.5 cm, but the escape rates were very different, 21.84% with protective bag and 75.34% without protective bag. While the weight of the catch amount in the two trawls net were found nearly the same, the weight of escaped catch was found twice more for the catch without protective bag (39.55 kg) than that with protective bag (18.19 kg) (Table 2).

The mean L_{50} values were 16.44 and 14.75 cm for without and with protective bag, respectively. The SR values were 6.17 and 12.28 for without and with protective bag respectively. The protective bag significantly affects L_{50} and SR values for brushtooth lizard fish ($P < 0.05$) (Table 3). The selectivity curves of brushtooth lizard fish were shown by the distribution of the total length caught and for escape with and without protective bag in Figures 1 and 2, respectively.

Randall's threadfin bream

A Total 152 of Randall's threadfin bream were caught in this study. In two positions of trawl codend, size of the fish ranged from 8 cm to 22 cm; in addition, the escape rates were similar, 15.84% with protective bag and 13.06 % without protective bag. The weight of total and escaped trawl catches were close (Table 2).

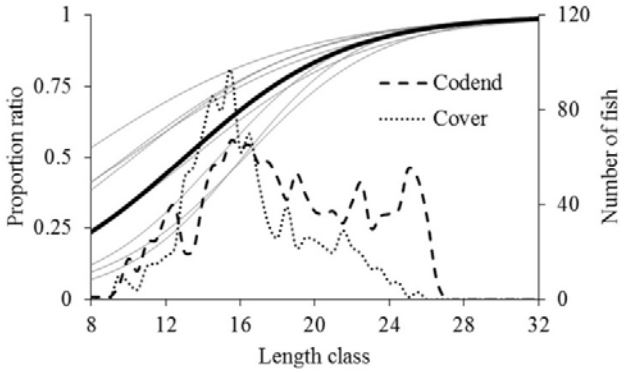

Fig. 1 — In with protective bag selectivity curves and length distribution of Brushtooth lizard fish in 44 mm open mesh of trawl codend. (Y-axis left: percentage retained for selection curves, Thin lines: individual hauls; thick lines: mean curves, Y axis right: Number of the fish, dashed line: codend; dotted line: cover fish).

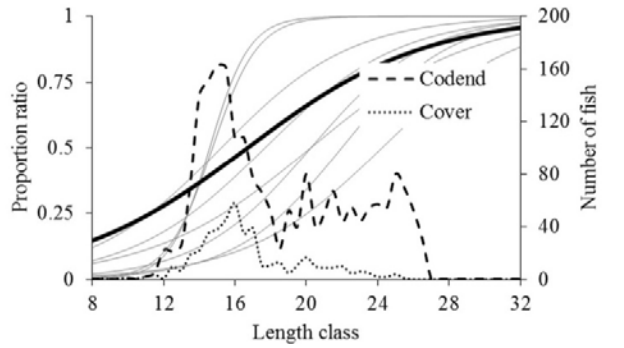

Fig. 2 — In without protective bag selectivity curves and length distribution of Brushtooth lizard fish in 44 mm open mesh of trawl codend. (Y-axis left: percentage retained for selection curves, Thin lines: individual hauls; thick lines: mean curves, Y axis right: Number of the fish, dashed line: codend; dotted line: cover fish).

The mean L_{50} values were 9.34 and 10.02 cm for without and with protective bag, respectively. SR values were 3.45 and 1.8, for without and with protective bag respectively. The protective bag significantly did not affect L_{50} and SR values for Randall's threadfin bream ($P < 0.05$) (Table 3). Selectivity curves of the Randall's threadfin bream

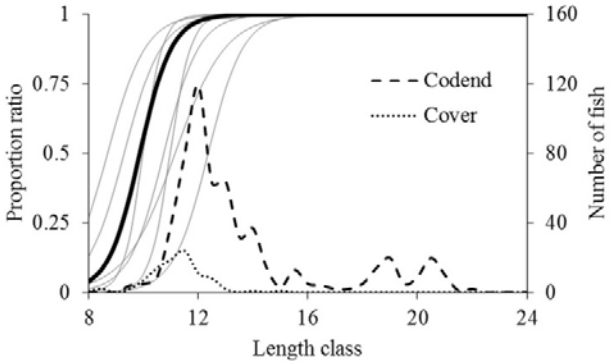

Fig. 3 — In with protective bag selectivity curves and length distribution of Randall's threadfin bream in 44 mm open mesh of trawl codend. (Y-axis left: percentage retained for selection curves, Thin lines: individual hauls; thick lines: mean curves, Y axis right: Number of the fish, dashed line: codend; dotted line: cover fish).

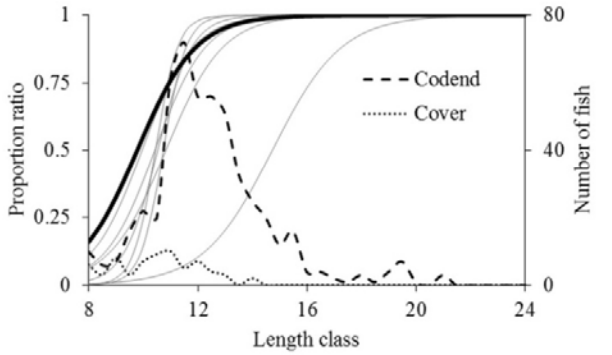

Fig. 4 — In without protective bag selectivity curves and length distribution of Randall's threadfin bream in 44 mm open mesh of trawl codend. (Y-axis left: percentage retained for selection curves, Thin lines: individual hauls; thick lines: mean curves, Y axis right: Number of the fish, dashed line: codend; dotted line: cover fish).

were shown by the distribution of the total length caught and for escape with and without protective bag in Figures 3 and 4, respectively.

Discussion

Results of this study show that the use of the protective bag circumference with 44 mm mesh PE netting significantly affected the L_{50} and SR values for brushtooth lizard fish. These results clearly indicated that the size selectivity of such codend has a negative effect for the fish species. In the case of the other dominant species, Randall's threadfin bream, the use of the protective bag had no effect on L_{50} and SR values at first glance in the trawl fishing. In fact, the selectivity rates for this species were very low for Randall's threadfin bream in both cases, without and with protective bag.

On the codend selectivity, the use of the strengthening (protective) bag, mesh size and number of meshes in the codend were important for saithe, red mullet and hake in trawl fisheries[16-18]. However, in a similar study, the use of the protective bag surrounding the codend did not significantly affect codend mesh selectivity for red mullet (*Mullus barbatus*), annular sea bream (*Diplodus annularis*), picarel (*Spicara smaris*) or common pandora (*Pagellus erythrinus*) in Turkish demersal trawling that used 84 mm nominal mesh size protective netting around 44 mm mesh[1].

In this study, the most important difference noted was the few amounts of catch in the fishing trawl operation session in Iskenderun Bay. The sharp decline for catches was because of various reasons, especially the pressure of trawl overfishing[19]. According to regulations, the fishing season starting in September showed an ever-decreasing amount of catch for decades (Unpublished, region fisheries managerial data). For this reason, it was asserted that in the area trawl, the fishermen struggled for more effective fishing by preventing escape of fish from trawl codend mesh opens.

In addition, the shallow depth of the Iskenderun Bay trawl fishery was also suggested to be an opportunity for the reduction of escaping for trawler of the region when compared to other trawl fishing areas. As the trawl hauling depth increases, the trawl codend multiply oscillates and the trawl codend meshes open in diamond shape[20]. When the mesh opens, a significant part of the escapes come to the foreground preventing the fish from escaping in strained and closed mesh[21].

Conclusion

Two inferences of the study were: (1) the trawl codend size selectivity is very low for many demersal species by 44 mm diamond mesh in Iskenderun trawl fishery and (2) The brushtooth lizardfish was more prone for escaping codend mesh than other demersal fish species due to its fusiform body structure and swimming ability[22]. The use of the protective bag circumference has a negative effect even for brushtooth lizardfish.

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